New ways to learn science with enjoyment – Robotics as a challenge

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Abstract*. It is well known that during their learning process youngsters prefer and enjoy exciting challenges, so that they don't get bored in school. Many of those challenges are blossoming all around the world in an annual basis, and they stimulate students because they create new objectives, they allow creativity, discovering new and unique solutions and allow comparison of the work carried out by other teams.*
The robotics interest has been growing quickly and many schools are adopting this knowledge area due to its multidisciplinary, for being stimulating, for allowing students creativity, for being so practical and hands-on, and it technologically sounds good.
Many challenges have being created in the last few years, both pedagogical and competitive, and requiring different levels of know-how.
This paper describes the most important robotics challenges in terms of it main objectives and rules, the age target, its geographical localization, its average budget and the first steps to be taken for new teams. After reading this paper teachers will be able to decide which robotic challenge is more suitable for his team.

Keywords. Mobile and Autonomous Robotics, Events, learning experience, Science, youngster, Hands-on.

1. Introduction

To bring up successful Engineers for the future, the teaching of science to youngsters is extremely important. Multidisciplinary and hands-on projects at early stages can enrich their skills and allow them to feel and experience the difficulties of a real challenge.
The development of Robotics is a good example of such projects. Amongst others, the main advantages for the students consist of acquiring knowledge in various areas such as electronics, programming, communications, mechanics, etc., the experience of working in group, the development of real physical prototypes built by themselves, and also the possibility of participating in robotics competitions with other teams and getting the possibility of comparing their work and discussing it with other people. Above all, this is easily become in the end, a rewarding learning experience.
Many new teams are emerging and many others are willing to start this new challenge but sometimes they can find difficulties to start and to get information regarding robotics.
This paper tries to elucidate about the first steps and the first competitions to participate on. It does not describe all the robotics events worldwide due to lack of space but the ones that are most relevant.

2. Motivation

Many excuses are heard from some teachers NOT to start such challenge.
This is not my field of knowledge – that is not an excuse because anyone can read and learn about the field, there are many introductory books, the level of understanding to build a junior robot is not very high, and above all it is possible to ask help to another teacher to get involved.
There is no budget for such a project – That is also not an excuse because most components are cheap and some others you can find at home. Even recycling is an option, since used motors and sensors from old devices can be used in such robots.
I will not be a team member because this is for youngster and I am too old – The experience of an adult is always important to guide youngsters. Also, teachers must accept that they learn much with the students during these projects. Students are normally very creative and they integrate ideas from other projects building up unpredictable but working solutions, from which everyone can benefit.
Sometimes, it is the students who come up with the idea of building a robot and the teacher should not avoid their project. The teachers should help and support them. A motivated team

is a group of people which will not create problems to the teacher and they become much friendly than before.
It is also important to point out that participating in competitions dignifies not just the team but above all the school which they belong too. When a team has the robot built, they can participate in competitions and the name of the school will be used.

3. Where to start

There are many robotics kits which you can buy off the shelf and build by yourself [1] [2] [3] [4] [5] [6] [7] [8]. They come with a building manual and in the end you get a fully working robot, but just that. But, if you want to participate in competitions, you must bear in mind that each one has its own rules, regarding dimensions, autonomy, tasks to perform, type of sensors, etc. Therefore, you should first decide in which competitions you would like to participate and only then you decide the robot to build. Following, there is a brief description of the most important events on which you can participate.

3.1 First LEGO League (FLL)

The FIRST Lego League (FLL) is an international competition for young students (ages 9-16), organized annually by FIRST [9]. There are so many participants that, there they had to separate on local, regional and national competitions before the final which normally is held around April or May.
The contest focus a different science related topic, and the themes used so far were:
1999 - Mission of astronauts in a space station
2000 - A volcano eruption
2001 - The Arctic Impact
2002 - City sites related tasks
2003 - Mars rover mission
2004 - Problems related with disabled people
2005 - Ocean odyssey Marine tasks
2006 – Nanotechnology
2007 - Alternative energy
2008 - Climate of planet earth
2009 – Transportation
2010 – Biomedicine (still to come)

The scenario is completely built out of LEGO bricks and each team has to design a robot (also made of LEGO bricks only) to fulfil the required tasks, build the robot and program it. There are several tasks but these are normally very simple.

Figure 1. FLL Scenario (2004)

This is a LEGO based event, where participants need to buy a special robot based LEGO kit (one or more, depending on the desired degree of complexity).
There are two types on sale: LEGO MindStorms with RCX controller (first version) and a more recent version with the NXT controller [10]. The prices may vary depending on the countries but it will cost around about 200-300 Euros (each box). The box comes with hundreds of LEGO parts, manuals to build many robots, software to program them, proper cables to link the construction to your computer, etc.
The LEGO parts are standard and it is well known that everyone can build LEGOS, which makes the mechanical build up very easy. Then, the programming part is also very accessible because the software environment has a nice graphical user interface which works with objects that are very easy to program. The programming instructions are so simple that the box targets 11 years old kids.
More information about this league available on http://www.firstlegoleague.org/

Figure 2. FLL LEGO robot - RCX controller

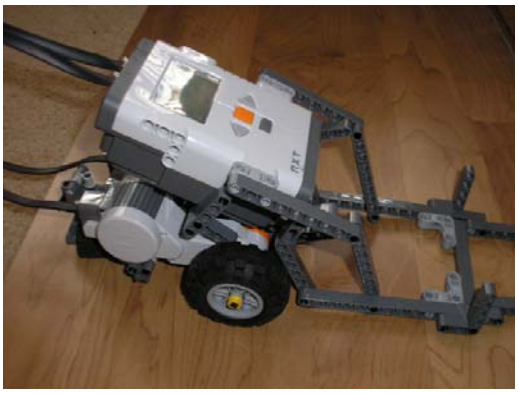

Figure 3. FLL LEGO robot - NXT controller

3.2 Eurobot

The Eurobot [11] competition was first held in 1998, and started as a national competition in France but soon became an international amateur robotics contest open to teams of young people (school projects or private clubs). Participate on Eurobot students from secondary school up to university level. Mostly held in France this event was also organized in Switzerland, Italy, Germany, etc. The number of participating teams is over 200 (in France) and then the best three teams of each country get together in the final.
The main objective consists of building amd programming a mobile robot to perform a certain task, different every year. The missions so far have been:
1998 - Football
1999 - Castles Attack
2000 - Fun Fair
2001 - Space Odyssey
2002 - Flying Billiards
2003 - Heads or Tails
2004 - Coconut Rugby
2005 - Bowling
2006 - Funny Golf
2007 - Robot Recycling Rally
2008 - Mission to Mars
2009 – Temple of Atlantis
2010 – Feed the World (still to come)

In this event, always compete two teams on the board, trying to eliminate each other. The winner continues on the competition and passes to the next round.
The budget to build a robot to participate on this challenge can be something between 3 or 4 hundred Euros, up to a couple of thousands, but one should bear in mind that it is highest budget that wins, but the team with more creativity.

Figure 4. Eurobot official table

The know-how required to build such a robot is relatively high.
Apart from the robotic competition, this is an amazing event gathering fun, high technology, friendship, creativity, education and passion. The environment is very friendly, with lots of activities for youngsters, parties, etc., and youngsters just love it.
More information about this league is available on http://www.eurobot.org.

Figure 5. Minho team Robot on Eurobot

3.3 Micro-Rato (Micro-Mouse)

This robotics competition is a Portuguese event organized by the University of Aveiro and started in 1995 with his students [12]. It is a one day event held annually in May and consists of a 5m by 5m maze where the robots have to find the way out in the shortest time, guided by infrared sensors. The challenge is the same every year although a few minor changes are implemented. Participate university students and in the last few years some secondary schools dared to

participate and they are having good results. The complexity of this challenge is between the First LEGO League and the Eurobot. The number of participating teams rounds about 20. First a technical inspection is made on the robots, and then the teams participate on rounds. The best times go forward until the final. On each round 3 robots participate at the same time, so that they have to avoid collisions with each other.

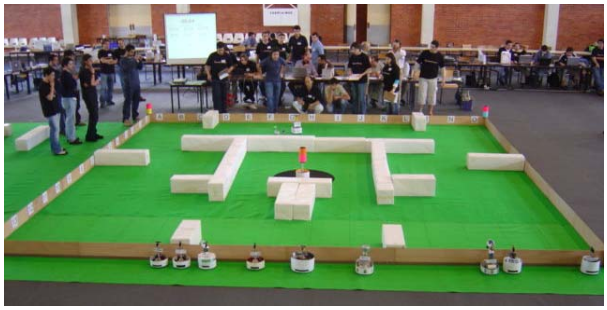

Figure 6. Competition Maze

Rules are available on http://microrato.ua.pt/ (unfortunately, only on Portuguese). There is no standard robotic kit, and this challenge is more suitable for electronics students. The budget to build this type of robot can vary between 100 and 400 Euros.

Figure 7. Two robots built for Micro-Rato

3.4 RoboCup

Originally called as Robot World Cup Initiative, consists of an international research and education initiative [13]. The idea is to foster Artificial Intelligence and intelligent robotics research by providing a standard problem where wide range of technologies can be integrated and examined. The football was the main challenge. The idea is to build a team of autonomous robots able to play and win against a human team, by the year 2050. Soon other challenges appear, like the rescue league, the RoboCup@home league, and leagues for juniors.

This scientific challenge started in 1997 in Nagoya (Japan) and since then has been organized annually all around the world, being the next edition in 2010 in Singapore. The last edition received around about 200 participants from 35 countries. Due to the high number of teams willing to participate, each country has a national competition where the best teams are chosen. In Portugal, Robotica [14] is the official tournament and it is held annually in a different location. It started in 2001 in Guimarães and the next edition is in 2010 in Leiria/Batalha.

There are three junior leagues [15] and these are describe next: Football, Rescue and Dance. On each of these leagues there are two age groups: Primary goes up to 14 years old, and Secondary from 14 to 18 years old.

The level of complexity of these robots can vary very much. Most teams can compete there.

3.4.1 Football or Soccer Junior

Each team has to build two robots able to play football in a green field (carpet). The ball used transmits infra-red signals in many directions so the robot can recognise it. The goals are coloured one in yellow and the other in blue. There is a human referee. The robots can be built using the LEGOS or built by the team members using traditional electronic components. Rules available on http://www.robocupjunior.org

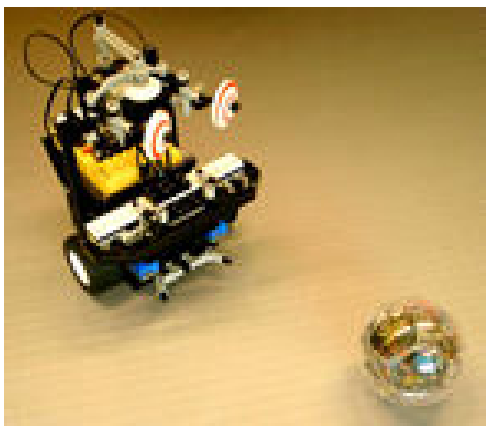

Figure 8. Football junior robot (Primary)

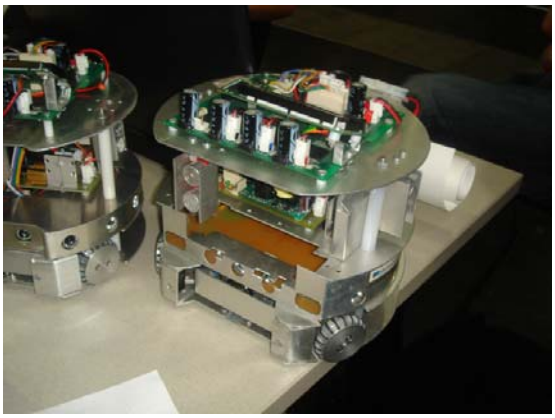

Figure 9. Football junior robot (Secondary)

3.4.2 Rescue Junior

On the Rescue league, the teams have to build one robot able to move in a two levels scenario which contains a black line on a white background, with some victims on the line (figures of man laying down) in two colours (green and gray).

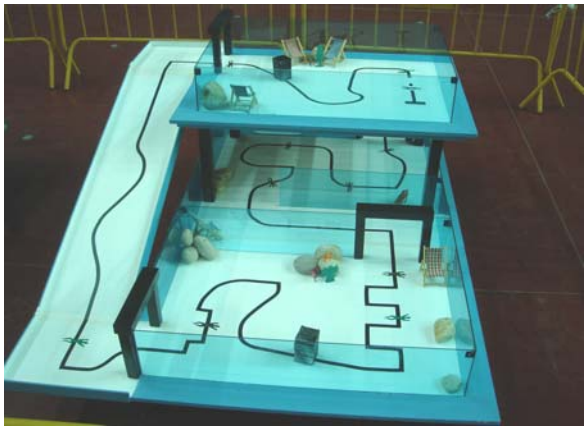

Figure 10. Rescue junior scenario

The robots have to follow the black line, count the number of victims, signal it with LEDs, move to the upper floor (going up a ramp). For each successful task the team receives points and for failed tasks the team is deducted points. There is also a jury to mark the points of the game.
The rules for this league can be seen on http://www.robocupjunior.org

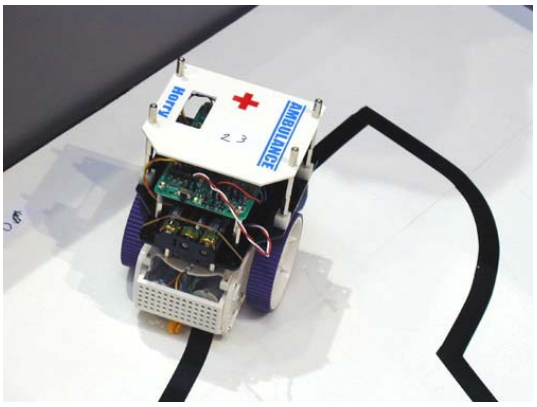

Figure 11. Rescue junior robot (Primary)

Figure 12. Rescue junior robot (Secondary)

3.4.3 Dance Junior

This league gives students more creativity freedom. The main objective is to have robots performing in a stage with music. They are responsible for the robots build up, the choice of music and its choreography, as well as the robots dressing. The human team mates can also perform at the same time as the robots, during the two minutes total time. Some teams make robots dance, some others create bands, where the robots play music, some others perform a play with music as background, etc. A jury will award points regarding the robot build up, programming, robot and team members dressing, subject chosen, number and type of sensors used, number of false stars, etc… Rules available on http://www.robocupjunior.org

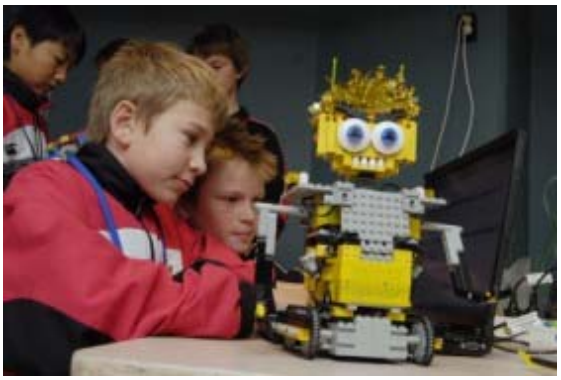

Figure 13. Dance junior robot (Primary)

Figure 14. Dance junior robot (Secondary)

3.5 RoboParty – Educational Event

All robotics events consist of competitions between students who build the robots at school or at home. RoboParty [16] has a different approach because the robots are built in the event. It is an annual event organized by the Automation and Robotics Group [17] of University of Minho [18] and by SAR – Soluções de Automação e Robótica [19]. They developed from scratch a robotic kit to be built by people with no knowledge at all in robotics and called it Robot Bot'n Roll ONE [20]. In this event students are taught how to build a robot, how to program a robot, and they can also participate on an optional small competition.
The main purpose is then to teach and not to compete. This is dedicated to those people who want to learn how to build a robot.

Every year around February or March, 100 teams are accepted to participate on RoboParty which lasts for 3 consecutive days and it runs 24 hours a day. Teams are made up of 4 people (one adult and 3 youngster) ages between 10 years old and 19 years old. No one from the team needs to know anything about robotics, because there is a specially created training on the event to teach the first steps. In the last few years, some teams were made up of a family (mother, father and 2 kids).

The event consists of lecturing the basics of electronics (how to assemble an electronic board and they have to actually solder the components), mechanics (to build the structure), programming the micro-controller (to make the robot move). All these lectures were developed taking into consideration their age and lack of knowledge on robotics and therefore cartoons were used on the slides to explain simple basics. The teams is accompanied by some 50 volunteers (last year students of industrial electronics degree) in order to help them should some problem occur. In order to avoid an intense period of knowledge acquisition, extra activities also occur like horse riding, golf, tennis-table, football, woodball, basketball, cardio fitness, kick boxing, karate, yoga, indoor air modelling, circus activities, etc… Since so many participants came from so far, the organizing committee prepared 400 gymnasium mattresses and lay them down on the pavilion (parallel to the working area) where they can sleep. About half of them were so enthusiastic that did not sleep at all and continued working full night.

In the last day, there are a few optional small competitions, where they can participate with the robot they built to test their capabilities. The competitions are:
Obstacles – The robot is placed in a small maze and it has to come out without colliding with the walls.
Pursuing - two robots are placed on a closed black line. Each robot has to follow the line until it catches the opponent.
Dance – Each robot has 90 seconds to perform a dance. The choice of music and choreography is chosen by the team.
Engineering – The robot is analysed by electronic engineers and they assess the quality of the build up.
Aesthetic – The most beautiful and original robot is the winner.

Awards are given to the three best qualified teams on each of these competitions. There are also sports competitions in parallel and the winners also receive awards.

Each participating team brings a laptop computer and sleeping bags, and the receive at reception a box with all parts to build the robot, manuals, t-shirts, canteen tickets, badges, posters, a form to apply to the extra activities, etc. After the competition the robot belongs to the team (they can take it home). They also take home an official RoboParty diploma stating that they successfully built the robot. The organization also guaranties that all robots leave the event fully working.

As bottom line the participants learn and build robots, learn many areas of knowledge, met new people, got souvenirs, met the facilities at the University of Minho (including sport facilities), and take a robot home with them. The building rate success has been over 95%. Some of these robotic platforms have been used in other robotic competitions (like RoboCup and Robótica) which means that the students continued developing the robots and improving the software to their needs.

Figure 15. RoboParty training session

Figure 16. Participants assembling robots

Figure 17. Extra activities – Tennis table

Figure 18. Robots built on display

Figure 19. Pursuing competition scenario

4. Main advices for beginners

For those teams who would like to start in these activities, a few advices are left here:

Robotic Kit – Bot'n Roll (www.botnroll.com)
Events – RoboParty (www.roboparty.org)
RoboCup (www.robocup.org)
WWW – www.robocup.org
www.robocupjunior.org

Books

- Robots - From Science Fiction To Technological Revolution, by Daniel Ichbiah
- Robot Building for Beginners, by David Cook
- Robot Builder's Bonanza, by Gordon McComb
- Absolute Beginner's Guide to Building Robots, by Gareth Branwyn
- Intermediate Robot Building, by David Cook
- Robot Builder's Sourcebook, by Gordon McComb

Movies

- I, Robot
- Robots
- Wallie
- 2010 space odyssey

Spaces - Robotarium X, Alverca, Portugal

5. Conclusions

It is important for young students to start working with science and robotics due to its multidisciplinary.
Mobile robotic competitions are important because students get very much involved on the subject, they work in group, they compare their work with other schools, etc. A competition is a good work form as it provides students a specific and stimulation goal. The projects are fun and stimulating so that the motivation and desire to make an effort in the course is high.
The main advantages in short term are that they participate in educational projects, students get more motivated to continue learning and they get competences in different scientific areas.
In long term, probably more students decide to continue their studies (at University level), there will be more chances of blossoming technological companies, new technological solutions in civil areas, etc.
Participation on this kind of events is relevant not just for students but for teachers, not just because they can also learn but because the participating students are easier to teach.

6. Acknowledgements

The author would like to thank everyone in the Robotics Laboratory at University of Minho for all the support given in the organization of many events. A special thanks for all the staff at the SAR – Soluções de Automação e Robótica.
All the organising committee and volunteers deserve the recognition of their work.

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